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RETROGRADE FROM IRAQ (RFI)

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CENTER FOR ARMY ANALYSIS
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13. ABSTRACT *(Maximum 200 Words)*

In the fall of 2010, United States Forces-Iraq (USF-I) drew down to 50,000 service members and began Operation NEW DAWN. In order to support the Bilateral Security Agreement between the United States and Iraq, U.S. planners had to reposture two million pieces of equipment and retrograde the remaining service members by 31 December 2011. The Retrograde from Iraq (RFI) study was conducted in support of a request from the USF-I Chief of Staff, Major General William Garrett. MG Garrett requested support from the Center for Army Analysis (CAA) to assess USF-I's ability to achieve its reposture objectives. This effort included the closure of 92 bases. The RFI study provided forecasts on when all equipment would clear individual bases for base closure, when all equipment would leave Iraq, the level of utilization rates for various transportation resources, and the "velocity" of equipment as it departed. These analyses were conducted under varying transportation networks and planning factors. With the requirement to reposture more than two million pieces of equipment, these forecasts supported numerous key decision points with greatly enhanced information and reduced uncertainty.

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CAA-2011286

RETROGRADE FROM IRAQ (RFI)

SUMMARY

THE STUDY PURPOSE was to assess the effect of different courses of action on the transition of equipment from locations in Iraq to destinations in Kuwait.

THE STUDY SPONSOR was the Major General Thomas Richardson, Director, J-4, Headquarters, United States Forces – Iraq (USF-I).

THE STUDY OBJECTIVES were:

    (1) Determine when all equipment would depart Iraq.

    (2) Determine when equipment would clear individual bases for base closure.

    (3) Determine the utilization of various transportation resources.

    (4) Determine the "velocity" of equipment as it departs.

THE SCOPE OF THE STUDY included the reposture of approximately two million pieces of equipment.

THE MAIN ASSUMPTION was that the data provided by units and separates identifying their equipment turn-in schedules would closely reflect the actual movement requirements and schedule.

THE PRINCIPAL FINDING was that USF-I can achieve its reposture objectives under a wide variety of conditions.

THE STUDY EFFORT was led by Ms. Renee Carlucci, Force Strategy Division, Center for Army Analysis.

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1 BACKGROUND

In October 2010, The Center for Army Analysis (CAA) received a reach-back request from the United States Forces – Iraq (USF-I) J-5, Assessments Division. The USF-I Chief of Staff, Major General (MG) William Garrett, requested analytical support to assess USF-I's ability to achieve its reposture objectives including the closure of 92 bases and retrograde of forces. USF-I had just completed the drawdown from 150,000 to 50,000 service members. However, the new operations order would require the reposture of two million pieces of equipment and the redeployment of the remaining service members by 31 December 2011.

The Retrograde from Iraq (RFI) study team started by reviewing numerous files and briefings provided by USF-I as background and conducted a literature search on other work that had been done in the area of reposture and retrograde. A number of spreadsheet tools had been developed by various parties in the USF-I J-4, United States Army Central Command (ARCENT), and the 1st Theater Sustainment Command (TSC) to support the initial drawdown prior to Operation NEW DAWN. In addition, the Army Materiel Systems Analysis Activity (AMSAA) had developed a simulation in support of ARCENT and the Responsible Reset Task Force (R2TF). AMSAA's simulation was focused on retrograde activities in Kuwait and could not support MG Garrett's request. While that model would not be able to provide the specific insight needed for the current requirement, it did give the team ideas for how it could approach the problem. Coordination with AMSAA's analysts led to collaboration on a proof-of-principle simulation that specifically addressed the needs of USF-I leadership. In addition to the simulation, a number of tools were developed and used to reduce uncertainty and support decision-making.

The RFI analysis, completed in June 2011, provided the insight required to answer numerous inquiries from the USF-I Commanding General, Chief of Staff, and the USF-I J-4 about the redeployment process. Under varying transportation courses of action, planning factors, and assumptions, the study provided forecasts on when all equipment would clear individual bases for base closure, when all equipment would leave Iraq, what would be the utilization rates of various transportation resources, and what would be the "velocity" of equipment as it departed. With the requirement to reposture more than two million pieces of equipment, these forecasts supported numerous key decision points with greatly enhanced information and reduced

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2 PURPOSE

The purpose of the RFI study was to assess the effect of various courses of action on the transition of equipment from origins in Iraq to destinations in Kuwait. These courses of action were established as part of the operations order development process for the complete withdrawal of American troops per the presidential directive to be out of the country by the end of the year. Logistical planning for this move was considerably complex due to interactions between many varied organizations and units, as well as uncertainty in the amount and locations of equipment to be moved. As part of the logistics rehearsal of concept (ROC) drill process, units developed equipment turn-in schedules. These equipment turn-in schedules were combined into a database establishing the unit retrograde requirements from Iraq. The central task of the study was to determine the effect of these turn-in schedules on the overall retrograde of equipment and to assess USF-I's ability to meet its reposture objectives.

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3 SCOPE

3.1 Simulation

The study team determined that the best way to analyze the complex interactions would be through simulation. Each base within the Iraq Joint Operating Area (IJOA) was classified as a hub, spoke, or sub-spoke. The bases and the transportation network connections between them formed the foundation of the simulation.

Two fundamental processes are simulated in the model. The first is the process of equipment being turned in by the units and moved to either Redistribution Property Assistance Team (RPAT) yards or centralized receiving and shipping point (CRSP) yards. The second process is that of the equipment being moved as part of a convoy from base to base via the Iraq road network until it crossed the border into Kuwait. The simulation focuses on retrograde movements southward and the corresponding convoy movements northward that would be necessary to support the retrograde. It does not reflect all sustainment movements nor does it reflect internal unit movements within Iraq (i.e., as units reposture within Iraq). It also does not reflect the movement of empty containers to Kuwait other than those identified in the ROC drill database. Finally, it does not reflect activities that take place in Kuwait.

## 3.2 Verification and Validation

The simulation team started the project by talking to liaison officers from the organizations responsible for supporting retrograde operations in an attempt to build a conceptual model of how those operations would take place. These liaison officers were recruited to form a joint planning team (JPT). In order to gain a greater appreciation for the conduct of operations, the simulation team visited a RPAT yard and a CRSP yard located on the Victory Base Complex (VBC). At the end of February 2011, and in order to determine if the responses were sufficiently accurate for their intended use, the study team conducted a results validation by comparing the responses of the simulation with known or expected behaviors. Several authoritative data sources were used for this effort including radio frequency identification (RFID) information showing the movement of individual loads. Historical data collected by the 402nd Army Field Support Brigade (AFSB) during the first drawdown was examined to confirm historical process delays experienced by equipment between RPAT yard turn-in and availability for the next movement. Input was also taken from a series of ARCENT-sponsored Lean Six Sigma (LSS) studies to examine the various process steps and associated process times for activities after equipment turn-in. These LSS studies were leveraged within the simulation as well. The study team examined historical Joint Operation Planning and Execution System (JOPES) data from 2009 and 2010 to determine the intra-theater movement delays that equipment experienced between an origin in the IJOA and its destination in Kuwait. These historical movement delays were compared to the simulation results for validation.

3.3 Design of Experiment

Upon verification of the simulation model, the RFI study team ran an experimental design across five factors to do their analysis. The factors included convoy size, number of convoy escort teams (CETs), quantity of container handling equipment (CHE), yard delays, and movement requirements. The analysis examined the relative impact of the factors on equipment velocity as

well as the interaction of those factors. Not surprisingly, CHE and movement requirements had the largest impact on the response variables (average and maximum transit times). However, each installation had its own unique set of significant factors and the experimental design gave insight into what could be done to alleviate problems based on the situation.

4 APPROACH
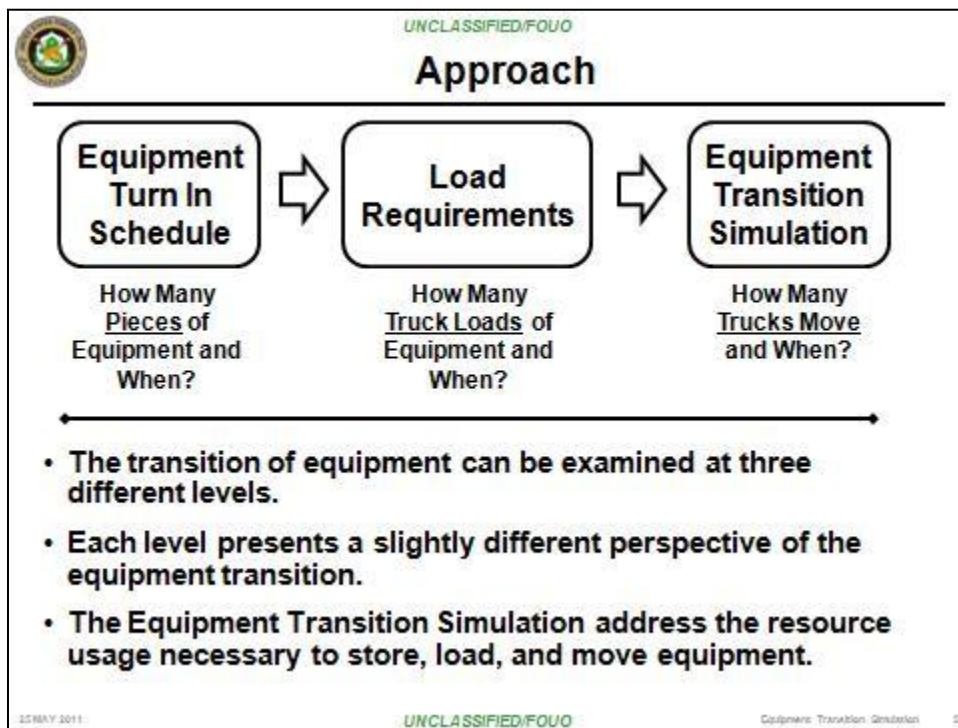
Figure 1 Approach

As shown in Figure 1, the RFI study approach can be broken down into three levels of analysis. At the most fundamental level, the equipment turn-in schedule identifies how many pieces of rolling stock (RS) and non-rolling stock (NRS) units will turn in on certain days at each base. Additionally, the turn-in schedule communicates the disposition of each piece of equipment. Disposition is important because if there is a piece of theater provided equipment (TPE), it will receive different handling than a piece of equipment that is going to self-deploy.

At the next level of analysis, the turn-in schedule is converted into the number of truckloads needed to move this equipment. Without simulating anything, this level of analysis gives decision makers a good sense of the volume of demand that will be placed on the transportation network.

The final level of analysis simulates the storage, loading, and movement of equipment in an effort to identify issues that may arise as a result of the interaction between different resources.

4.1 Equipment Turn-In

A number of tools were developed and implemented to reduce uncertainty and support decision-making about equipment turn-in. One of the earliest tools analyzed the unit turn-in schedules and allowed the staff to visualize and synchronize events across the theater. The tool allowed the staff to quickly identify those units that had planned to turn in equipment either just prior to or even after base closure. This technique for analyzing the turn-in schedule was so effective that it was integrated into the data collection process so that data entry errors could be automatically identified and corrected when data were entered.

4.2 Load Requirements

One of the early challenges for USF-I and the Country Container Authority (CCA) was to determine the number of containers required for the retrograde. As discussed above, units and other organizations submitted data to reflect their equipment turn-in schedule in terms of the number of pieces of RS and NRS items. The data they entered described the date of turn-in, location, the number of pieces of RS and/or NRS, and whether the equipment was "Sensitive" or "Non-Sensitive" ("sensitive" cargo was defined by the Defense Travel Regulation as prohibited from commercial shipping). Sensitive cargo had to be shipped via military convoy to Kuwait.

Although the units provided the number of pieces of RS or NRS to be retrograded, further analysis was required to determine the number of containers, flatbeds (FBs), and heavy equipment transporters (HETs) needed. Converting this information into load requirements involved great uncertainty for the staff due to the thousands of non-standard line item numbers (LINs) on unit hand receipts. Most of these non-standard items had no dimensional data listed in any of the institutional databases.

Analysts from CAA researched the dimensions for thousands of these items. To facilitate planning, the J-4 wanted an estimate of how many items could be packed in a container. This data collection enabled making gross container estimates by weight and volume. Not only did this analysis support the RFI study team, but it was passed on to analysts at the Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA) for incorporation into their loading models to develop better estimates for containers and transporters. Up until February 2011, CAA could only validate dimensional data for 57% of the sensitive NRS and 6% of the non-sensitive NRS, with sensitive items accounting for 85% of the property book NRS. Given the limited data available, CAA's initial estimate was 129 items of NRS per twenty-foot equivalent unit (TEU) container.

This estimate was significantly lower than the planning factor used by J-4 (300 pieces of NRS per TEU) and nearly tripled the estimated number of containers required. J-4 was hesitant to reduce their planning factor, while the simulation team advised using the most conservative estimate. This was an item of contention discussed in the logistics ROC drill.

Three factors influenced this discussion : 1) The study team demonstrated that the overall impact of a 100-item per TEU vice a 300-item per TEU planning factor was negligible on the overall movement requirements since NRS only constituted 17% of the identified movement requirements; 2) A historical analysis of the first drawdown's NRS movement requirements was done, which resulted in an estimate of 195 items per TEU; and, 3) By mid-March, through painstaking research, the study team had identified dimensional data for 62% of the sensitive NRS items on the Country Property List, which was equivalent to 199 items per TEU. This analysis corroborated the historical analysis and convinced the J-4 planners to adopt the 195 pieces of NRS per TEU planning factor.

A similar controversy arose regarding what planning factor to use for RS. A historical figure from the first drawdown provided by 1st TSC assumed that 47% of RS would require a HET, while 53% would require a FB. Based on preliminary analysis of the property book, J-4 planners suggested reducing the planning factor from 47% to 25%. However, analysis completed by SDDCTEA analysts on the March property book demonstrated that 40% of RS could require a HET.

4.3 Transportation Requirements
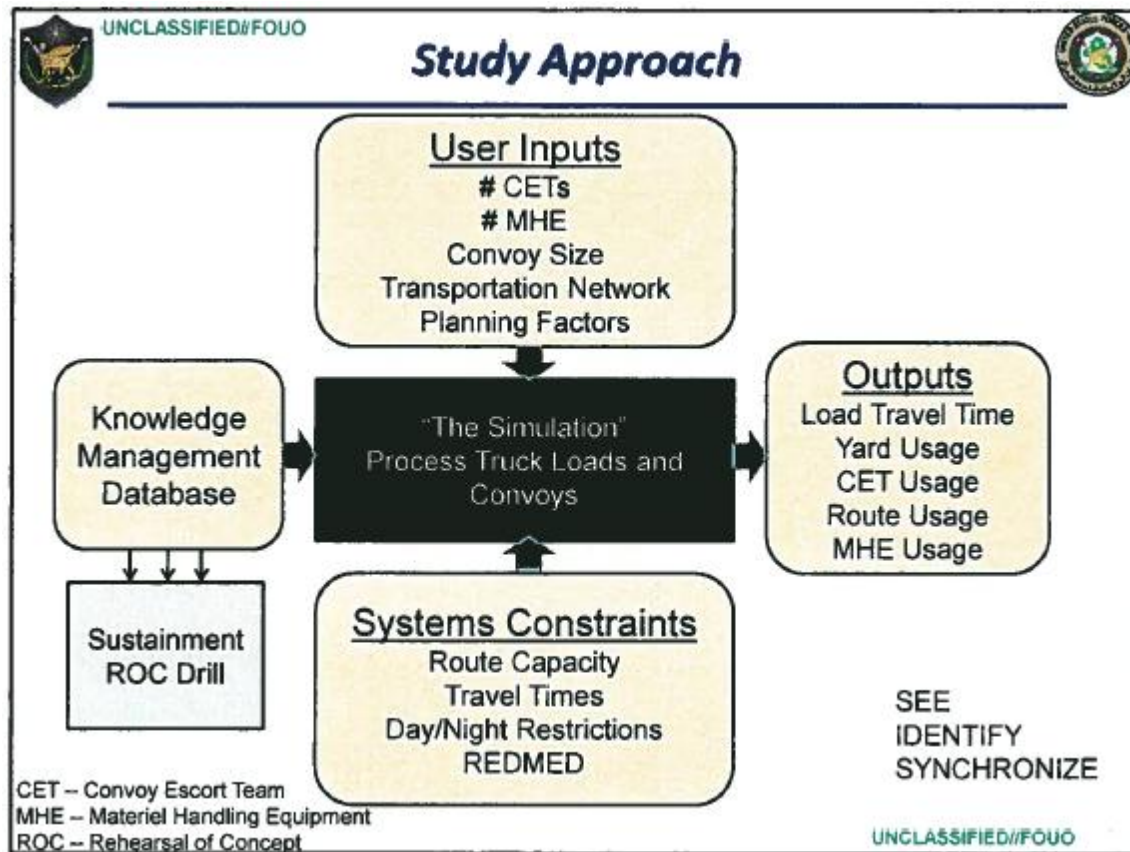
Figure 2 Equipment Transition Simulation

As mentioned previously, a discrete-event simulation was built to simulate the transition of equipment from their origins in Iraq to their destination in Kuwait. As demonstrated in Figure 2 above, the simulation used the ROC drill data that had been processed into truckloads as input. These truckloads were characterized as either a HET carrying RS or a FB truck carrying RS or containers (two TEUs per truck). This cargo could be organic equipment (unit-owned) or theater-provided equipment. To simulate the movement of these loads through the transportation network, information was gathered on the input variables affecting movement and constraints. The input variables included the number of trucks that constitute a convoy, the number of CETs, the number of FBs and HETs, and the number of CHE (i.e., ramps and rough terrain container handlers (RTCH) at a base). The transportation network defining how cargo would flow and what unit would handle cargo was one of the most important inputs provided and constituted the backbone of the simulation. Route restrictions can result from a variety of causes including bad weather (known as REDMED because of the grounding of medical evacuation helicopters and local route closures), religious observations, and enemy activity such as protests or increased improvised explosive device (IED) threats. Routes could also be constrained, allowing convoys to travel only during the day or at night in order to reduce threats or to reduce impacts to residents. The simulation allowed planners to rapidly examine the impact of a variety of conditions and planning factors on the transportation-related resources and on the transition of equipment.

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5 ESSENTIAL ELEMENTS OF ANALYSIS

Figure 3 Essential Elements of Analysis

Figure 3 shows the Essential Elements of Analysis (EEA) or study questions for the project. The Measures of Effectiveness (MOE) listed below each EEA show how the study questions were evaluated. Transporters use the term "velocity" frequently in their line of business. The study team found that term to be alternately defined as the ability to move equipment without delay and the transit time divided by the total time from equipment turn-in to delivery. One can imagine that sometimes allowing cargo to sit (accumulate) at a base in order to amass a larger group of resources to move may be more efficient than sending convoy assets immediately to pick up a small load. Therefore, options that maximized "velocity" were not necessarily efficient.

At the start of this study, it was believed that the question of when the last load would leave Iraq would be the most important to answer with other questions key to answering the first question. The second question was initially considered a mere curiosity. But it quickly became clear that the transition of individual bases was the most important goal in the system. Obviously, if the transportation system can clear every base on time, it can clear the IJOA on time.

Secondly, while there was an initial concern that "velocity" (the ability to move equipment without delay) was going to be critical, it became clear that there would be times when it was operationally necessary to delay some equipment to ensure the timely transition of a base.

By restructuring the terms of the discussion and showing the interaction of different aspects of the transportation system, the simulation played a central role in establishing confidence that sufficient assets existed to conduct the transition and that the transportation network was sufficiently robust to handle challenges.

6 MODELED PROCESSES
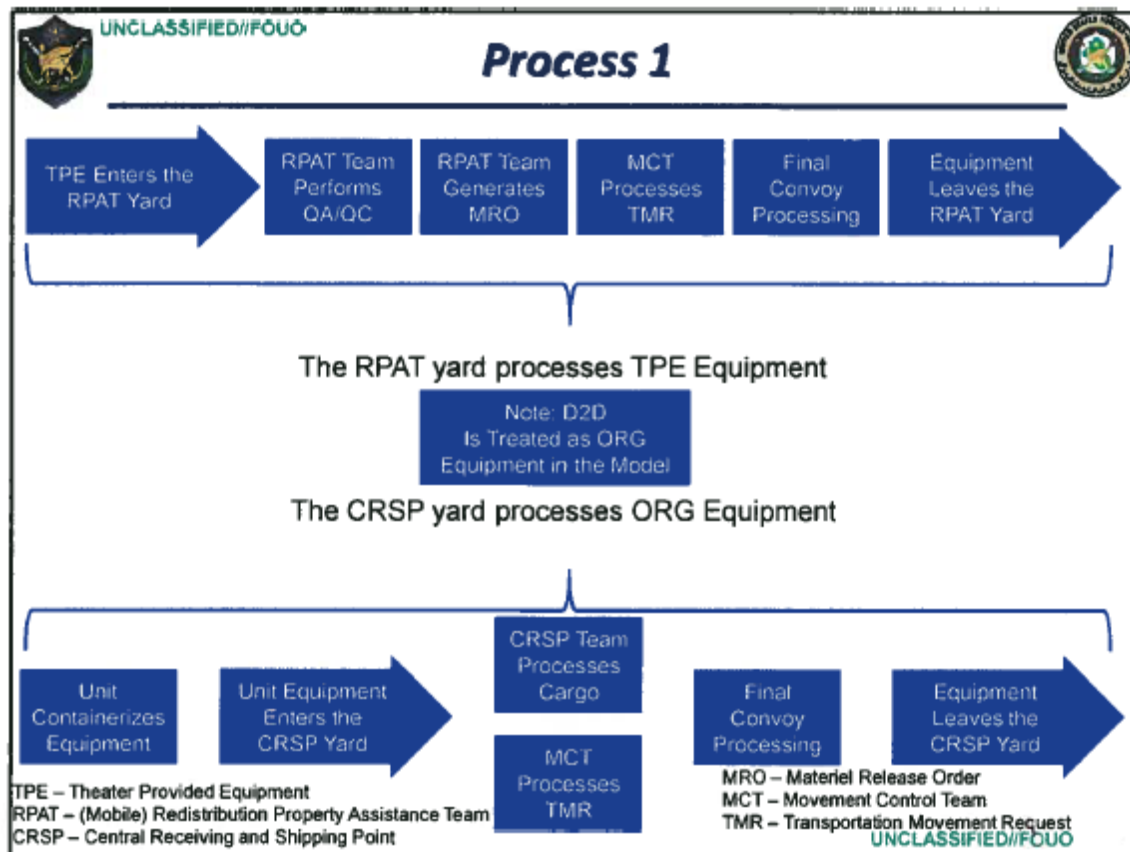
Figure 4 Simulated Process 1

Figure 4 describes the first process represented in the simulation. Units turn in their organic or TPE equipment to their local CRSP or RPAT yard for further movement. The cargo first must obtain space in the yard. Yard space was set at a very high capacity to make it unconstrained. In part, this is because many transporters say that they can "find space in the desert to park stuff". However, this technique proved useful to track the number of loads in the yard and related resources required to support it.

Once the load arrived in a yard, the cargo has to be offloaded requiring either ramps or CHE. The simulation uses a triangular distribution to reflect the varying process times to offload the cargo using ramps and RTCHs. If the cargo is TPE, it experiences a delay in the yard to reflect all the process activities for the cargo's property book ownership to be transferred from the unit to the 402nd AFSB as well as to generate the paperwork required for onward movement of this equipment. Organic equipment does not have the same delays as the unit would have already submitted the Theater Movement Request for its cargo prior to turn-in at the CRSP yard. Cargo at both the RPAT yards and CRSP yards is accumulated until there is a convoy's worth of cargo for pick up. A planning factor of 30-vehicle loads is generally used to constitute a convoy.
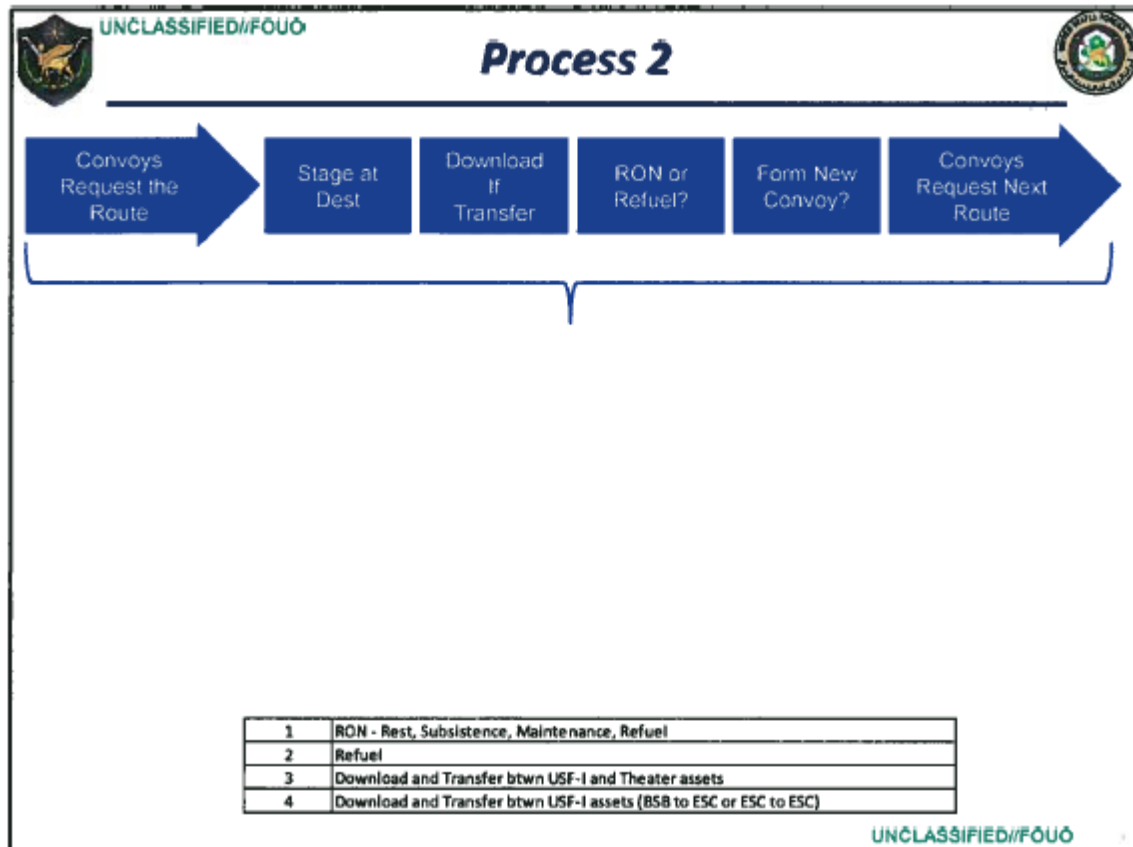
Figure 5 Simulated Process 2

Once the convoy commander has signed for the cargo, it must be loaded on vehicles. Once again, the cargo requires resources, either ramps or CHE, in order to be loaded onto the convoy vehicles. After the convoy is loaded, the yard space can be released and the route capacity for the convoy is committed. The J-4 planners have determined which organizations will be responsible for moving cargo based on a unit's origin and how that cargo will move through the transportation network. The convoy capacity of a route was computed based on the distance of a given road segment and the 10th Sustainment Brigade (SB) standard operating procedure (SOP) regarding the required vehicle spacing for a convoy. Once a required road segment has been committed to the convoy, the travel time is calculated based on a triangular distribution. The 14th Transportation Battalion collected historical travel times for convoys and provided the shortest, longest, and average travel times from checkpoint to checkpoint. As shown in Figure 5 and based on the planned transportation network, the convoy may either transload the cargo at the next destination for another handler to pick up, it may only refuel, or it may remain overnight (RON). RON and refuel times are also computed by triangular distributions based on historical data. At the next destination, yard space must once again be dedicated for the convoy. Then, if the cargo must be transloaded, any required ramps or RTCHs must be obtained in order to offload the cargo from the convoy vehicles. The cargo is then accumulated into a new convoy requiring transportation assets such as FBs, HETs, and a convoy escort team to take it to the next destination until it gets to Kuwait.

7 INPUT ANALYSIS

For assistance with developing input to the simulation model and in order to validate their planning factors, theater analysts requested an estimate of cargo movement requirements for redeployment. A team of analysts in the Mobilization and Deployment Division at CAA took on this effort and sought to provide an estimate of the cargo movement requirements in terms of the number of TEUs, HETs, and FB trucks.

The CAA team, led by Ms. Ashley Francis, proposed a two-phased approach to developing the cargo movement requirements. The first phase would examine data for NRS on the USF-I property book in order to estimate container requirements based on volume and weight. The second phase would involve tasking SDDCTEA to analyze the movement requirements for both NRS and RS using their Transportability Analysis Report Generator (TARGET) to determine TEU, HET, and FB requirements for the cargo. The first phase would serve as a preliminary estimate of the number of TEUs required, whereas the second phase would provide a more accurate estimate but also require an additional 2-week turnaround time for SDDCTEA to determine the cargo movement requirements via TARGET. Both phases required detailed knowledge of each of the LINs on the USF-I property book, which became an issue the team had to overcome.

Upon receiving the USF-I property book containing the listing of LINs by unit, the team began researching the LINs in Army institutional databases in order to obtain the length, width, height, and weight of the items. The team soon discovered that the majority of these LINs were non-standard LINs with no dimensional or weight data in those databases. In order to obtain the exact dimensions and weight of the non-standard LINs, the team began a time-consuming two-step process to research the items. The first step of this process involved researching the LINs in the SSN-LIN [Standard Study Number-Line Item Number] Automated Management and Integrating System (SLAMIS) to determine the manufacturer of the item. Analysts then conducted further research of the manufacturer itself to obtain dimension and weight data. In some cases, the manufacturer's website would contain a brochure with dimension and weight data for each item; in other cases, analysts had to make contact with the manufacturer via email or phone in order to obtain such data.

By February 2011, the team had found the volume and weight for 57% of the sensitive NRS items on the USF-I property book. Based on these data, the team completed the first phase and calculated a preliminary gross estimate of the number of TEUs required. This calculation consisted of summing the volume of cargo to redeploy and dividing this sum by the volume of a twenty-foot container with interior dimensions specified. This estimate served as a lower bound for the number of containers required to redeploy U.S. forces. After providing this estimate to theater analysts, the team of analysts moved on to the second phase of the analysis.

The team continued dimension and weight research for all LINs, beginning with sensitive RS items because the number of RS sensitive LINs was much lower than the number of NRS sensitive LINs. Upon completion of the research, they submitted these data to SDDCTEA for TARGET model runs. TARGET loaded the RS items on either HETs or FBs depending on the dimensions and weight of the item. The output of this allowed analysts to see the number of HET and FB loads required for 2011 redeployments, as well as the ratio of HETs to FBs required.

The research of the sensitive NRS items became more intensive because of the sheer number of unique NRS LINs on the USF-I property book. The time-consuming nature of this research, in addition to the thousands of non-standard LINs requiring such research, led the team to modify the approach for the second phase. They developed a new approach for NRS items that would split the USF-I property book into groups based on the month of redeployment for each unit. The team focused on the LINs one group at a time to develop the cargo movement requirements, allowing them to provide the container requirements by month of redeployment rather than for the entire 2011 time period. This enabled the team to provide a quicker response to theater's request for analysis and was appropriate because of the updates made to the USF-I property book over time.

The team continued LIN dimension and weight research for all units planned to redeploy in April, May, June, and July with sensitive NRS items. TARGET modeled the loading of twenty-foot containers for NRS items. Once the container estimates were provided back to CAA, analysts summarized the data by month and by location and provided these data summaries to theater analysts.

In using TARGET to simulate the loading of containers, CAA analysts were able to see exactly how many items were loaded into each container. The TARGET output provided the number of items loaded into TEUs for hundreds of containers, giving the analysts a sample with which to better approximate the aforementioned items per container planning factor. Analysts used these data to determine that the planning factor was, on average, 199 items per container. This supported the notion of reducing the planning factor of 300 items per container as previously discussed.

The results of this work had many different uses. It allowed a comparison of property book movement requirements to the data that units had provided in the ROC drill database. It allowed a validation of planning factors for the number of NRS items per TEU and for the number of RS items per HET and per FB. Finally, the TARGET model output could be utilized by units as load plans for their equipment, providing better estimates for their requirements for containers, FBs, and HETs.

In addition to the work described above, a Visual Basic for Applications (VBA) program was produced which utilized the planning factors developed above to process the ROC drill data into loads and create charts of the movement requirements over time for each logistics base. These charts allowed the staff to quickly visualize their challenges. Obviously, if units were turning too much equipment in on the same day, close to or even after a base closure date, this would make meeting base closure dates difficult or even impossible.

8 OUTPUT ANALYSIS
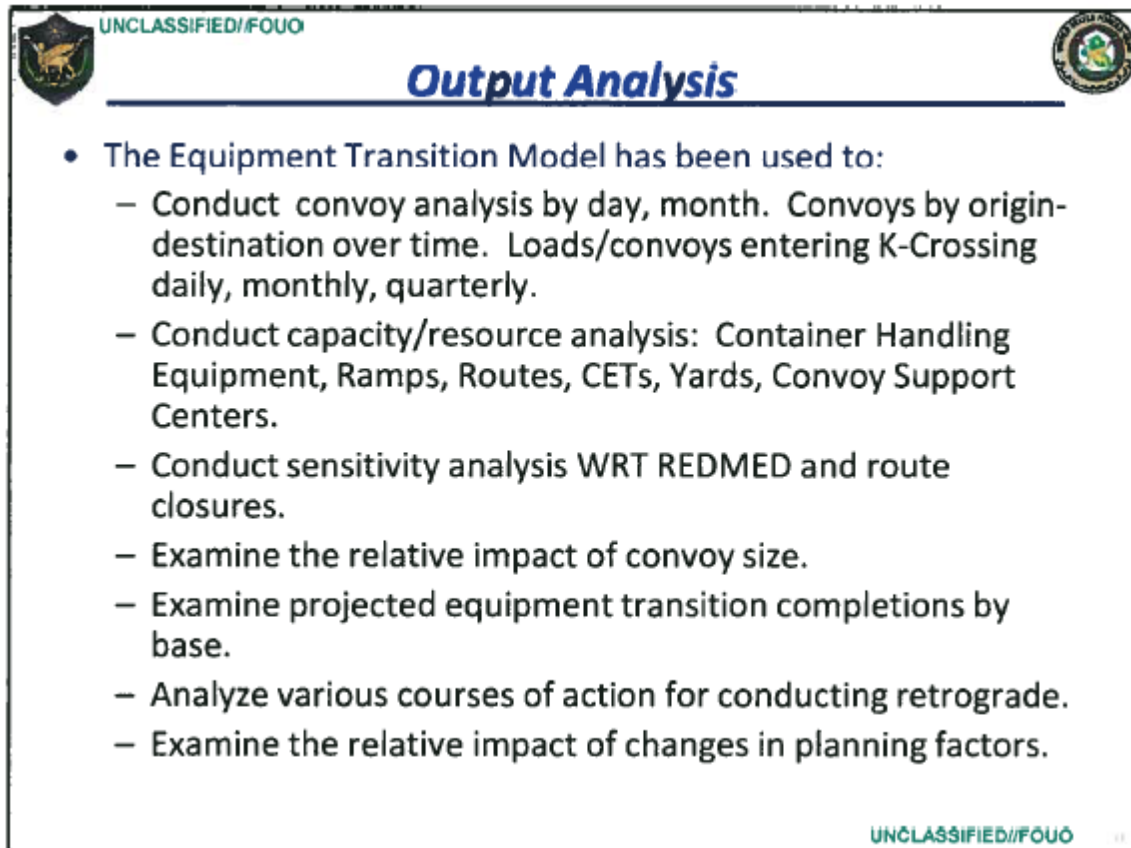
Figure 6 Output Analysis

Following the March 2011 logistics ROC drill and the completion of the Design of Experiment, the simulation model was used by the J-4 to support the transportation experts' decision-making. The simulation team began to provide numerous findings, as depicted in Figure 6, including: expected base and country transition times; the effects of bad weather; the effects of route closures; convoy analysis by day and month; convoys by origin-destination; loads/convoys entering Khabari Crossing daily (the Kuwait border crossing); capacity/resource analysis for CHE, ramps, routes, CETs, yards, Convoy Support Centers; impact of planning factors; and the impact of various retrograde courses of action.
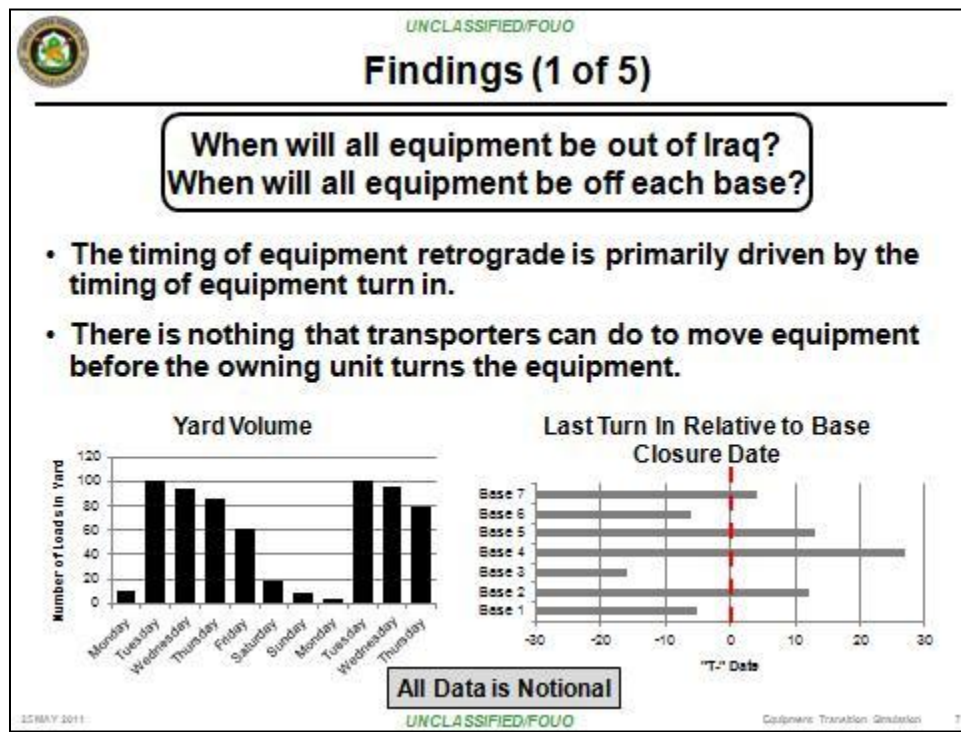
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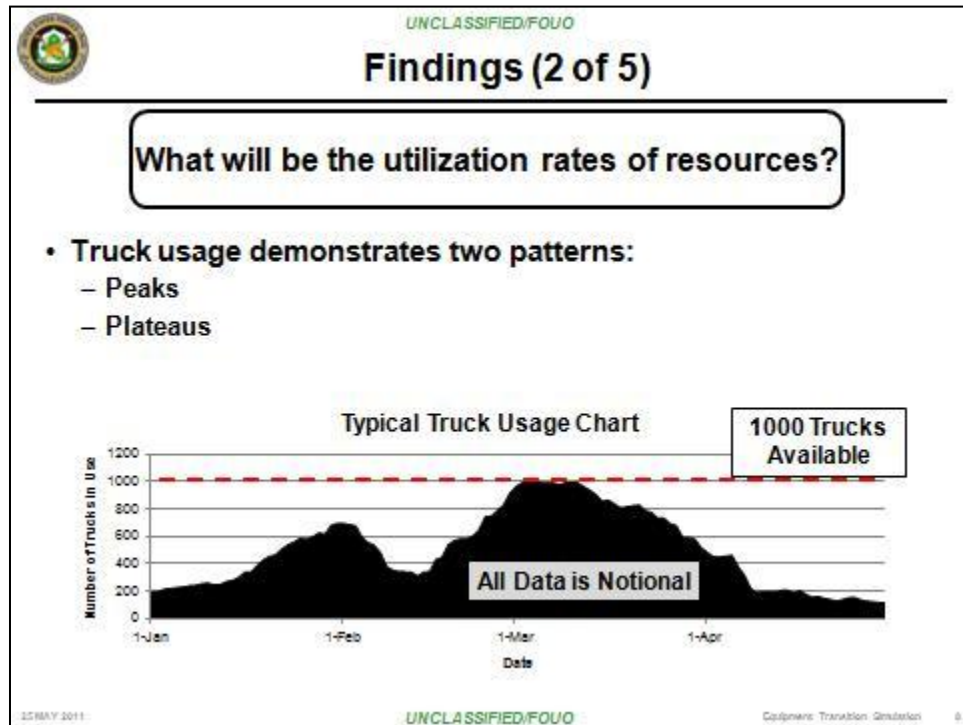
9 FINDINGS

Figure 7 Findings (1 of 5)

Due to the sensitivity of this ongoing operation, the answers to our EEAs and MOEs are not included in this report. Furthermore, as can be expected, the answers to our questions continually change as theater conditions and the operations order changes. However, we can address our findings in a general way.

When the study questions were developed there was an unstated assumption that the transportation network would get overloaded by the turn-in of equipment and that there might be a significant delay between the time when the last load was turned in and when a truck was available to move it. The simulation showed that the equipment turn-in schedule prevented this from being a serious concern. First of all, in most cases, the final piece of equipment to leave a base was equipment that was self-deploying. That meant that there was no real demand on the transportation network in the final phase of base closure.

Secondly, in many cases, the turn-in schedule left "breathing room" between turn-ins. Consider the chart in the lower left of Figure 7 above. At this notional base there are two equipment turn-ins scheduled about a week apart. As a result, the yard gets a spike in the number of loads on each Tuesday, but notice that between the two turn-ins, everything that is in the yard is shipped. In fact, the yard is able to ship so quickly that even if shipments were delayed by 1 or 2 days, equipment would not start backing up in the yard. This "breathing room" plays a key role in preventing major back-ups from occurring in the transportation system.

Finally, one of the things explored was the last turn-in at a base relative to the base closure date. This allowed planners to see where there were bases that planned to turn in equipment after the

base was supposed to be closed. This analysis played a key role in focusing planning for the equipment transition.


Figure 8 Findings (2 of 5)

Although the utilization rate of yards, material handling equipment, and routes were examined; the resource of greatest interest was trucks. In the notional example in Figure 8, there are 1,000 trucks available and demands of this resource are represented by the shaded area. The two dominant features of resource usage are peaks (such as the one shown in early February) and plateaus (such as the one that begins in early March). Peaks are the result of surges in demand that do not absorb all available resources. Plateaus are formed when there is a surge in demand that does absorb all available resources. In this second case, the plateau continues until all the demand is met.

The most notable concern was whether there were sufficient HETs and FB trucks allocated in the right locations to support the timely retrograde of equipment without the need to contract for additional assets. This comprehensive analysis confirmed transportation planners' estimates that an early additional contract would not be needed with a reallocation of theater assets.
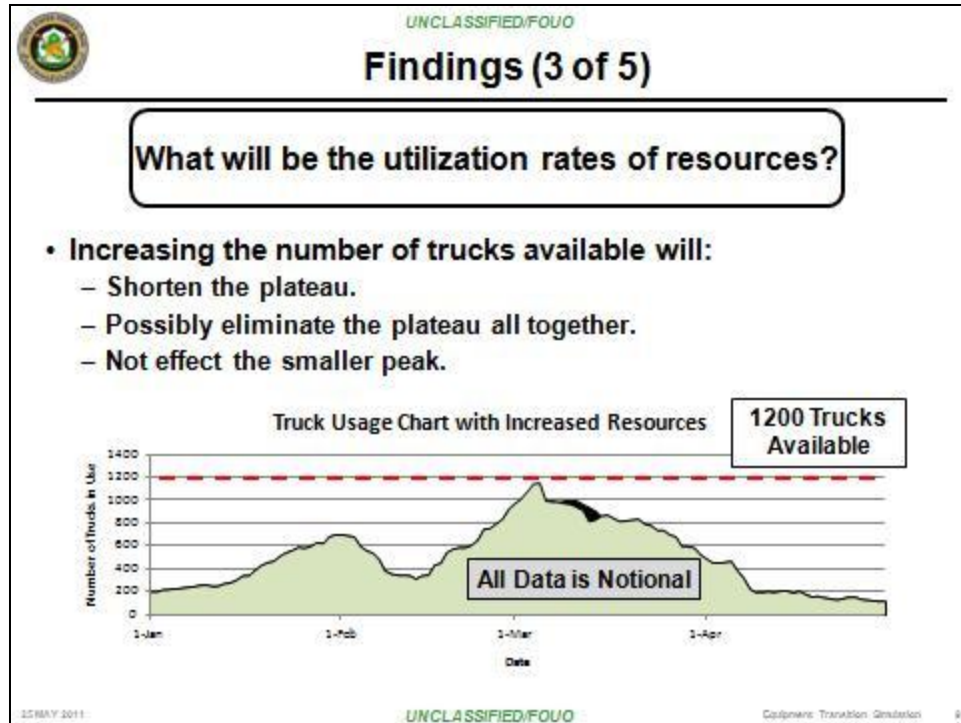
Figure 9 Findings (3 of 5)

What if the number of trucks that are available is increased (Figure 9)? First, the duration of the plateau will be reduced and if sufficient resources are made available, the plateau will be eliminated completely. This is not particularly surprising. What did seem to surprise some planners was that additional resources did not do anything to change the movement of equipment when there was not a plateau. This is another indication that the turn-in schedule is influencing the movement of equipment more than the transportation network. The study team's analysis also provided similar insights on requirements for containers, container handling equipment, ramps, convoy escort teams, yard space, and convoy support centers across the theater and over time.
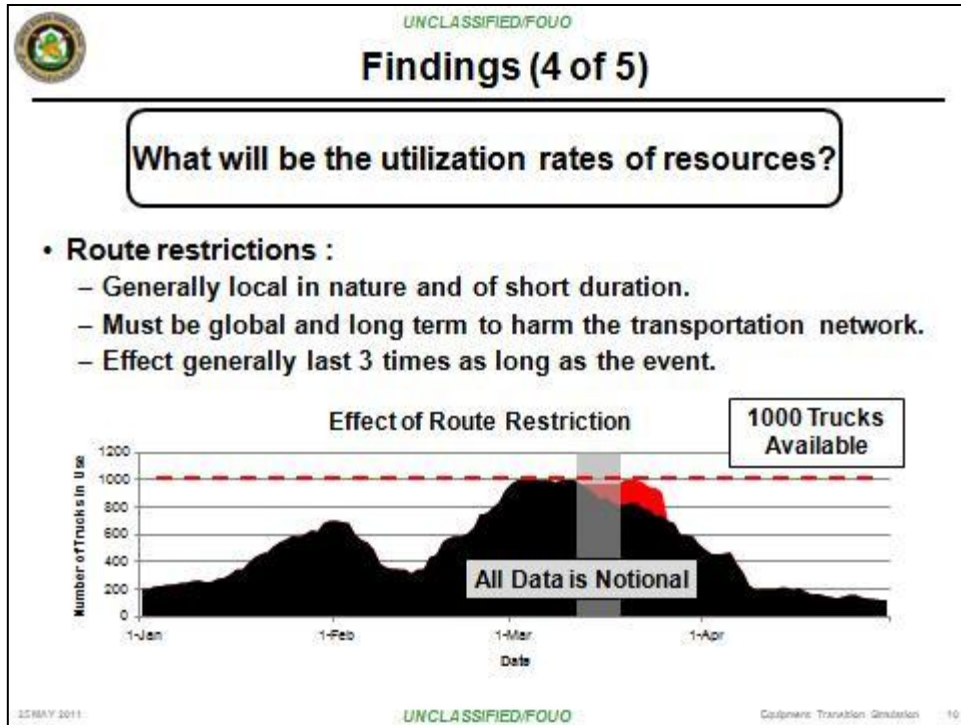
Figure 10 Findings (4 of 5)

Another concern of USF-I was the potential effect that route restrictions could have on the transportation network and timely transition of equipment. Route restrictions can result from a variety of causes including bad weather (REDMED), religious observations, and enemy activity such as protests or increased IED threats. In order to examine the impact of bad weather on the transition of equipment, the team collected historical weather data on conditions affecting the ability to fly medical evacuation helicopters. Data analysis was done on these historical data in order to fit a distribution for REDMED days. Based on this distribution, REDMED days can occur locally on a route and then absorb all of the convoy capacity of that route for 24 hours. If a convoy is already on the route, it will complete travel on that segment. However, no new convoys will be able to use the route until it has been freed from the REDMED day.

Similarly, events such as pilgrimages were scheduled to exclude convoys from utilizing appropriate routes. USF-I leadership has frequently closed routes to transporters for events such as the Hajj or Ashura. Some parametric analysis was done to examine the varying effects of REDMED and/or other events on the transportation network and the ability to transition equipment. The primary impact will be to affect resources locally as they get tied up in place awaiting the reopening of routes. However, given a proper equipment turn-in schedule and sufficient resources, the transportation network was shown to be sufficiently robust as to not be a major concern for planners.

This observation is important with respect to concerns mentioned previously. If the transportation network had been at risk of backing up, then route restrictions would only serve to exacerbate this problem. And it should not be surprising from what has already been discussed that the "breathing room" provided in the equipment turn-in schedule provides an opportunity for the network to recover from route restrictions.

Fortunately, route restrictions tend to be brief and local so that their impact is limited. Worst-case analysis has found that the only way to seriously delay the transportation network was to experience a route restriction that would affect the entire IJOA for more than a few days. Such a restriction is represented in the chart shown in Figure 10 by the grey bar. In black, the original truck usage data is represented. In red, the change that the restriction causes is shown. Note that when the restriction begins all trucks stop moving and remain in place until the restriction ends. Once the restriction ends, there is an increase in activity as all the trucks that were delayed begin to move, and empty trucks that were waiting to start movement also move.

An interesting pattern that was observed with route restrictions was that their effect lasted three times as long as the restriction itself did. During the actual restriction, nothing moves. Immediately following the restriction, all the movement that should have occurred during the restriction gets completed. Then in the third part of the event, equipment that piled up because it was not picked up during the restriction gets transported.
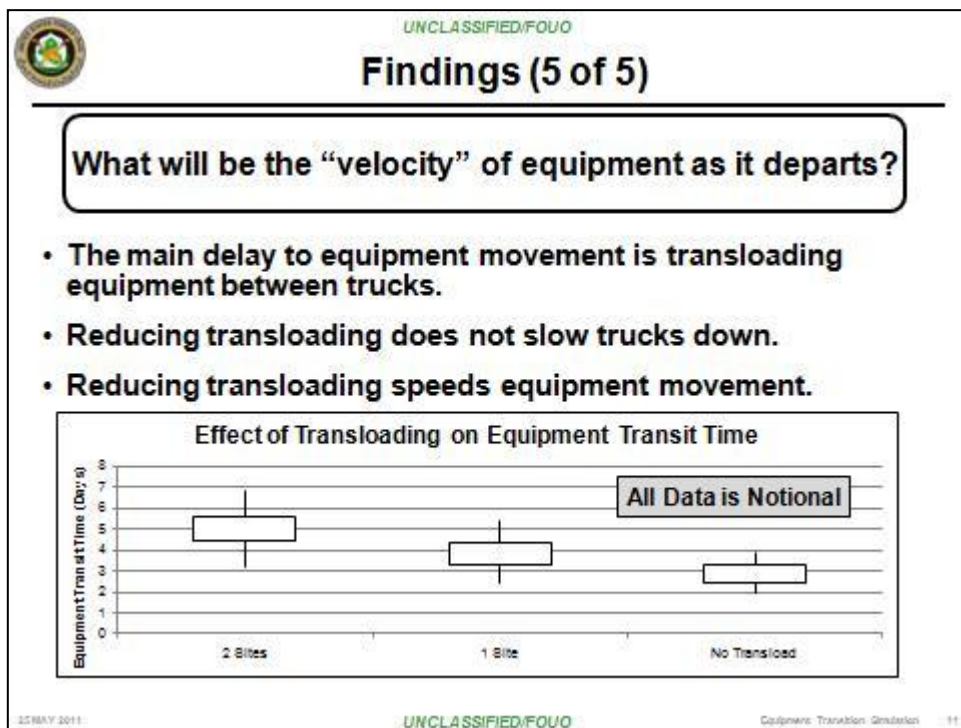
Figure 11 Findings (5 of 5)

One final area of analysis addresses the concept of "velocity", which measures the speed with which something moves through the transportation network. In most applications, this concerns the speed with which trucks are able to travel along a route. "Velocity" is less concerned with the speed that the drivers maintain when traveling than the total time that it takes to load, stage, move, refuel, download, and reset a convoy. During steady state operations in Iraq, "velocity" had decreased in priority. There were ample trucks available and "velocity" often had to be subordinated in order to deliver smaller loads to distant bases. In addition to "velocity" receiving a lower priority, transloading of equipment became a common practice. In some instances, containers would be handled three times before reaching their destination. This transloading of

equipment resulted in the "velocity" of equipment being reduced while the "velocity" of trucks remained relatively unaffected.

Since the transition of equipment out of Iraq was a primary concern in the operations order, analysis was conducted to determine what effect transloading equipment had on the flow out of the country. Figure 11 shows that when equipment transloading was reduced from two sites to one site, or eliminated entirely, there was a reduction in the time that equipment spent in the IJOA. Not only did eliminating transloading speed equipment out of Iraq, this was achieved without limiting the "velocity" of the trucks themselves. Further, this freed up significant materials handling equipment (MHE) that would have been otherwise tied up transloading the equipment and it reduced the complexity of paperwork. Although transloading of equipment was generally seen to be a restriction on the transportation network, it was recognized that there would be situations where transloading would be beneficial. This is particularly true when a base is close to its base closure date and has a large number of loads that need to be shipped out. Under this condition, it may be beneficial to take the equipment to the next base and have the available trucks return for a second load as quickly as possible.

Many of the analytical questions centered on examining the impact of various courses of action. Some of the pros and cons of a particular course of action are not readily weighed in the simulation, but must be taken into account along with the information that is provided by the simulation. For example, having convoy escort teams and convoy drivers maintain expertise on a dangerous road segment may be of value.

10 SUMMARY

The RFI analysis helped the USF-I make decisions about the scheduling of equipment turn-in, allocation of transportation assets, and organization of the transportation network. The study also assisted USF-I in discussions with ARCENT and the Government Accountability Office (GAO) concerning USF-I plans to meet its reposture objectives. The analysis provided numerous insights and enabled senior military leaders to make and communicate the best possible decisions.

The simulation validated the expectation of the transportation experts and played a central role in helping senior leaders understand how the transportation system would function. Although the findings of the simulation effort provided results that can be substantiated by intuition, the majority of these findings were not widely accepted before the analysis was performed.

The work of the RFI team expanded on the existing spreadsheet modeling that was being done by USF-I staff as part of their deliberate planning process. While the spreadsheet models provided estimates of the number of loads that would be turned in, the simulation process took this work further by determining the effects that varying activity times and resource utilization would have on the process. This expanded view of the variability and interdependence present in real operations allowed transportation experts to develop a better understanding of how different decisions would affect the transportation network.

Throughout the process of developing the simulation, the RFI team created a number of simple tools to reduce uncertainty and support decision-making. These tools emerged as time-saving devices for the RFI team but were quickly adopted by the USF-I staff speed their processes.

The broad scope of the project alleviated concerns and allowed rapid analysis of transportation courses of action. By providing rigorous analysis the RFI team helped the USF-I staff make significant refinements in the accuracy of their planning factors, which reduced the need for overly conservative estimates.

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APPENDIX A PROJECT CONTRIBUTORS

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APPENDIX B BIBLIOGRAPHY

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APPENDIX C SPONSOR'S ENDORSEMENT

HEADQUARTERS
UNITED STATES FORCES – IRAQ
BAGHDAD, IRAQ
APO AE 09342-1400

REPLY TO
ATTENTION OF:

USF-I J4

5 August 2011

MEMORANDUM FOR LTG ROBERT P. LENNOX, HEADQUARTERS, DEPARTMENT OF THE ARMY, DEPUTY CHIEF OF STAFF, G-8, 700 ARMY PENTAGON, WASHINGTON, D.C. 20310-0700

SUBJECT: 2011 Dr. Wilbur B. Payne Memorial Award Nomination for the Retrograde From Iraq (RFI) Study

1. It is with extreme pride that I commend the RFI Study Team for its outstanding contribution to the US Army. I strongly endorse this project for the 2011 Dr. Wilbur B. Payne Memorial Award for Excellence in Analysis.

2. The RFI analysis provided the insight required to answer numerous inquiries from USF-I Commanding General, Chief of Staff, and myself about the redeployment process. Under varying transportation courses of action, planning factors, and assumptions, the study provided forecasts on when all equipment would clear individual bases for base closure, when all equipment would leave Iraq, what would be the utilization rates of various transportation resources, and what would be the "velocity" of equipment as it departs. With the requirement to reposture more than two million pieces of equipment, these forecasts supported numerous key decision points with greatly enhanced information and reduced uncertainty.

3. Our most notable concern was whether we had sufficient Heavy Equipment Transporters (HETs) and flatbed trucks allocated in the right locations to support the timely retrograde of equipment without the need to contract for additional assets. This comprehensive analysis confirmed transportation planners' estimates that an early additional contract would not be needed with a reallocation of theater assets. The study team analysis also provided insights on requirements for containers, container handling equipment, ramps, convoy escort teams, yard space, and convoy support centers across the theater and over time. Another great concern was the potential effect that route restrictions could have on the transportation network and timely transition of equipment. Route restrictions can result from a variety of causes including bad weather (causing the grounding of medical evacuation helicopters and local route closures), religious observations, and enemy activity such as protests or increased IED threats.

4. The RFI analysis helped the United States Forces - Iraq (USF-I) make decisions about the scheduling of equipment turn in, allocation of transportation assets, and organization of the transportation network in support of the most dramatic force drawdown in US history. The RFI Study Team's efforts generated multiple tools for understanding the interaction of a wide range

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of variables effecting the retrograde of equipment out of Iraq. These tools made it possible to answer numerous inquiries from the USF-I Commanding General about the capability of the transportation network under uncertain conditions.

4. The comprehensive approach taken by the RFI Study Team allowed rapid analysis of transportation courses of action. Further, the flexible techniques employed permitted easy assessment of the impact that changing planning factors, time lines, and task organizations would have on mission accomplishment. Additionally, the level of detail built into the analysis permitted USF-I leadership to clearly visualize individual base closures, movement of individual loads of equipment, and utilization of resources. All of this combined to help understand and communicate how equipment would flow through the theater.

5. The RFI Study is without a doubt the most influential tool developed in USF-I in years. The study team provided responsive, high quality analysis in a creative way that enabled senior military leaders to make and communicate the best possible decisions. I highly recommend them for this award.

THOMAS J. RICHARDSON
MAJOR GENERAL, US Army
Director, J-4
US FORCES-IRAQ